Canadian Aviation Safety Board
Bureau canadien de la sécurité aérienne

Report on a special investigation into

Air Traffic Control Services in Canada

March 1990

REPORT
ON A SPECIAL INVESTIGATION INTO AIR TRAFFIC CONTROL SERVICES IN CANADA

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TABLE OF CONTENTS

	EXECUTIVE SUMMARY	1
1.0	**INTRODUCTION**	3
1.1	Background	3
1.2	Aim	3
1.3	Scope	4
1.4	Conduct of This Special Investigation	4
1.5	General Observations	5
2.0	**EQUIPMENT**	7
2.1	Modernization	7
2.2	Real-Time Surveillance on the North Atlantic	8
2.3	Direct Controller/Pilot Communications (DCPC) Over the North Atlantic	9
2.4	Technology Enhancements	10
2.5	Airborne Collision Avoidance System	11
2.6	Control Tower Layout	12
2.7	Indicator Modules (IMs)	12
2.8	Frequency and Telephone Availability	13
2.9	Head-Sets	13
3.0	**STAFFING**	15
4.0	**WORKLOAD**	19
4.1	Overtime	19
5.0	**TRAINING**	21
5.1	Training Production	21
5.2	Attrition	22
5.3	Instructor Availability	24
5.4	Instructor Training	24
5.5	Simulation	25
5.6	Refresher Training	25

6.0	**SUPERVISION**	27
6.1	Incentives to Supervise	28
6.2	Training for Supervisors	28
6.3	Quality Control	28
7.0	**OPERATING PROCEDURES**	31
7.1	Introduction of New Procedures	31
7.2	Transfer of Control	32
7.3	VFR/IFR Mix	32
7.4	Opening and Closing of Sectors	33
8.0	**HUMAN PERFORMANCE FACTORS**	35
8.1	Vigilance	35
8.2	Fatigue	36
8.3	Aeromedical Considerations	38
8.4	Visual Perception	38
9.0	**INFORMATION TRANSFER**	41
9.1	Callsigns	42
9.2	Phraseology	43
9.3	Coordination	43
9.4	Gander Paper Handling	44
10.0	**MANAGEMENT**	45
10.1	National Planning	45
10.2	Operational Decision-Making	46
10.3	Employee/Management Relations	46
10.4	Safety Promotion	47
10.5	Unit Evaluations	47
10.6	Investigation of ATS Occurrences	48
11.0	**CONCLUSION**	51
12.0	**ANNEXES**	
	Annex A	A-1

EXECUTIVE SUMMARY

Following a series of losses of separation between aircraft at Lester B. Pearson International Airport in Toronto in late 1988, the Canadian Aviation Safety Board decided to conduct a special investigation of the safety aspects of the current air traffic control situation in Canada. A detailed file review was conducted on 217 occurrences which had been investigated by either Transport Canada or the CASB. In addition, more than 80 interviews with representative controllers and users of the Air Traffic Services (ATS) system were conducted. No attempt was made to forecast operational requirements or assess technological capabilities beyond the end of the century. Nor was there any attempt to address capacity issues such as those imposed by current severe runway limitations at Toronto and Vancouver. Rather, the focus is on resolving current safety shortcomings in the system.

The special investigation showed that the Canadian ATS system handles thousands of flights daily, and losses of separation between aircraft are infrequent. Nevertheless, the unsafe conditions that from time to time develop to the point where there is a real risk of collision are cause for continuing concern. Safety deficiencies were identified in the areas of equipment, staffing and workload, training, supervision, operating procedures, human performance factors, information transfer, and management.

This report includes 48 Aviation Safety Recommendations to improve on the current levels of safety in the provision of air traffic control services in Canada. In many cases, appropriate remedial action has already been initiated by the Department of Transport. For example, programs like the Radar Modernization Project and the Canadian Automated Air Traffic System are well advanced.

The most serious shortcoming in the provision of air traffic services today concerns the availability of sufficient qualified air traffic controllers to meet the increasing operational demand. Due to the long lead-times required, resolution of this serious shortcoming will take several years. Innovative measures beyond those traditionally used by the Government of Canada may be required.

While this special investigation has not been exhaustive, the data examined and the witness statements provided are representative of problems with serious safety implications across the country. Although the ATS system is operating well in most respects, urgent Ministerial attention to the major issues addressed in this report is required to correct the identified deficiencies and to ensure the safe separation of aircraft in Canada. In particular, the current staff shortages must be redressed in order to facilitate implementation of many of the recommendations.

Success in sustaining the requisite levels of safety will be predicated upon the Government's recognition of the breadth and depth of the problems and its assurance of the necessary resources to correct the growing shortcomings.

1.0 INTRODUCTION

1.1 Background

From time to time, since its inception in October 1984, the Canadian Aviation Safety Board (CASB)* has been concerned over the level of safety in the provision air traffic control (ATC) services in Canada. Staff and Board Members monitoring Transport Canada's Civil Aviation Daily Occurrence Reporting System (CADORS) noted the frequency and potential gravity of occurrences with a risk of collision — either on the ground or in the air. Following a review of the overall situation, in May 1986, the Board convened a public inquiry into the problems of potential conflicts between aircraft and between aircraft and vehicles on the ground. The CASB's report on that special investigation was made public in August 1987 and included 28 Aviation Safety Recommendations to reduce the risks of collisions involving aircraft on or near the ground at Canadian civil airports. The response by the Department of Transport to these recommendations was generally quite favourable, and numerous actions have been initiated to reduce the frequency of occurrences with a risk of collision on the ground.

Subsequently, the Board continued to examine safety issues deriving from the risks of collisions between aircraft in flight. Occurrence data on operating irregularities in the provision of ATC services were examined for system-wide safety deficiencies. Based upon this analysis, a CASB project was undertaken for the investigation and analysis of ATC occurrences involving large passenger-carrying aircraft. Work on this project continued into the late fall of 1988.

Following a series of losses of separation between aircraft at Lester B. Pearson International Airport (LBPIA) in late 1988, the Board met with key representatives of the Canadian aviation community to discuss the safety aspects contributing to operating irregularities in the provision of ATC services in Canada. Pursuant to these discussions, the Board called upon the Minister of Transport to cause an independent public inquiry to be convened to address all aspects of the Canadian ATC system — including issues of management, airport capacity, and efficiency of the ATC system. The Board also decided on 21 February 1989 to conduct a Special Investigation of the safety aspects of the current ATC situation in Canada.

1.2 Aim

The objectives of this Special Investigation were as follows:

a) To identify safety deficiencies in the Air Traffic Services (ATS) system contributing to occurrences involving loss of separation between aircraft in flight under the control of a Canadian ATC unit; and

b) To make recommendations to alleviate these safety deficiencies.

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* See Glossary for all abbreviations and acronyms.

1.3 Scope

The scope of this Special Investigation was confined as follows:

a) The investigation and analysis were limited to those aviation occurrences that:

— involved at least one aircraft operating under instrument flight rules (IFR) and aircraft weighing more than 5 700 kilograms;

— occurred in the Toronto or Vancouver Terminal Control Areas (en-route traffic within these terminal control areas was considered only as it affected arrivals and departures); or

— occurred en-route in high-level airspace under Canadian control.

b) Factors deriving from airport capacity limitations, aircraft equipment, or flight-crew capabilities were only included to the extent that they affected controllers' or flight crews' abilities to safely fulfil their responsibilities with respect to maintaining safe separation of aircraft in flight.

1.4 Conduct of This Special Investigation

A special database including 710 occurrences which took place between 01 January 1985 and 31 December 1988 was created. Of these, comprehensive data were available on only the 75 which had been investigated by the CASB and the 362 which had been investigated through Fact Finding Boards conducted by Transport Canada. From these 437 occurrences that had been investigated, a random sample of 217 incidents from Toronto, Vancouver, and high-level airspace was selected* for a detailed file review by CASB safety analysts.

More than 80 interviews were conducted with representative controllers and managers in Vancouver, Toronto, Montreal, and Gander. In addition, discussions were held with representatives of the ATC Occupational Health Program, the Canadian Air Traffic Control Association (CATCA), the Canadian Airline Pilots Association (CALPA), the Air Transport Association of Canada (ATAC), the Canadian Business Aircraft Association (CBAA), with personnel of the ATS Training Centre in Cornwall, Ontario, and with personnel of Transport Canada Head Office.

The professional services of two retired air traffic controllers were retained to assist in the preparation of a comprehensive staff report which analysed the material acquired through the detailed file review, a literature search, and the interviews held with representative personnel. Discussions were again held with the principal representatives of the aviation community to confirm the technical accuracy and balance of the staff report.

This Report on the CASB's Special Investigation into Air Traffic Control Services in Canada therefore draws upon the factual basis of the Canadian occurrence record, as well

* This sample included over 60 per cent of the incidents at Toronto and Vancouver, 58 per cent of the high-level domestic airspace incidents, and 37 per cent of the North Atlantic incidents in the special database.

as the collective views of the many people who participated in this Special Investigation. It is deliberately presented in a summary format. (The CASB Staff Report is available for those wishing more background to the findings and recommendations contained in this report.)

1.5 General Observations

The Canadian ATS system handles thousands of flights daily, and losses of separation are infrequent. By almost any standard but that required for aviation safety, the error rate in the ATS system would be considered to be remarkably low.

Throughout this Special Investigation, the CASB has been impressed by the dedication and willingness of all the controllers and managers who participated to meet the operational demands SAFELY — regardless of how difficult. Indeed, even when the criteria for the separation of aircraft were violated, more often than not there was little or no real risk of collision. Nevertheless, the unsafe conditions that do from time to time develop to the point where there is a real risk of collision are cause for continuing concern.

This Special Investigation Report is the culmination of more than a year's concentrated efforts. It has examined in considerable detail, as well as from the broadest perspectives, the contributing factors to potentially dangerous loss-of-separation occurrences. There are few quick fixes. The pursuit and maintenance of safety in the provision of ATC services will be a never-ending quest.

There have been no midair collisions involving aircraft over 12,500 pounds maximum take-off weight in Canada since 1970. However, the vast majority of the 710 reported incidents in the 1985 to 1988 period involved at least one large aircraft (maximum take-off weight of more than 50,000 pounds or 23 000 kilograms), operated by a scheduled operator, flying under IFR. The majority of the reported incidents were technical losses of separation rather than serious risks of collision. Evasive action by one or both aircraft was reported in 19 per cent of the incidents.

The number of occurrences is higher than expected at the busiest airports. It is not surprising that incidents increase as airports become busier. However, an analysis of four years' data for some 60 airports suggests that the number of incidents increases approximately as the square of the number of movements. This is reflected in relatively high numbers of reported incidents at Toronto and Vancouver.

Human performance factors were assigned by the CASB's safety analysts in 88 per cent of the 217 files selected for detailed review; planning errors, judgement errors, and lapses in attention accounted for almost 60 per cent of these.

In 43 per cent of the occurrences, staffing considerations were noted; either a supervisor was working a control position or an inadequate number of staff was on duty at the time of the majority of these occurrences. Indeed, the staffing shortages at the busiest Area Control Centres (ACCs) are critically affecting the ability of the ATC system to provide IFR services. Supervisors are often filling operational control positions during most of their time on duty, thereby compromising the quality of the supervision given to the operational controllers. Rising workload at these Centres is exacerbating the staff-shortage situation. Therefore, heavy reliance is placed upon the use of voluntary overtime by controllers to keep all essential

operating positions open during peak periods; (the only practical alternative is to restrict traffic). Because of the current remuneration formula for overtime, a few controllers are accepting an excessive number of overtime shifts during their scheduled days off.

The current staff shortage is being exacerbated by the inability of the ATS training system to meet the operational demand for controllers. Attrition rates, both in basic training and during qualification training at operational units, are considered to be excessively high. The length of time required to qualify a controller for an operating licence is also considered to be excessive. Although Transport Canada has forecast a "get-well" date of 1994 wherein there will be a sufficient number of operational controllers to meet operational demands, this projection may be overly optimistic.

Transport Canada is placing heavy reliance upon equipment modernization to improve controller productivity. If the Canadian Airspace Systems Plan (CASP) can be implemented in full without slippage, an appropriate margin of safety for related problems should be maintained in Canadian Domestic Airspace. However, should the major programs of the CASP be delayed, for whatever reasons, serious questions remain about the near-term gains possible in controller productivity through equipment modernization.

In 44 per cent of the files reviewed, operations factors were found to be present, usually involving procedural, coordination, or supervisory considerations. There was some evidence of controllers cutting corners to handle current traffic levels with current controller availability. Furthermore, there was some confusion expressed with respect to the correct interpretation of some standard operating procedures.

Safe air traffic control is highly dependent upon effective information transfer. The occurrence record shows that at least half of all ATS losses of separation have causal or contributory factors which are directly attributable to breakdowns in the information transfer process — usually in oral communications.

From a national management perspective, the most serious problem facing the ATC community has been shortcomings in the effective planning for the training and maintenance of a full and productive operational controller workforce. Partly as a consequence of this planning failure, there appears to be some fundamental breakdowns in effective employer/employee relationships.

This Special Investigation has also highlighted shortcomings in the current processes followed in Canada for the investigation of incidents involving the loss of separation between aircraft. On the one hand, the CASB investigates selected incidents involving a risk of collision against one set of standards of investigation; on the other hand, Transport Canada investigates those occurrences not investigated by the CASB to a different set of standards. These different approaches have resulted in shortcomings in the information available for safety deficiency identification and validation.

The balance of this Report summarizes the more critical safety deficiencies identified in the comprehensive staff report and includes 48 Aviation Safety Recommendations to improve the level of safety in the provision of ATC services in Canada. The recommendations are organized to follow the principal themes of equipment, staffing and workload, training, supervision, operating procedures, human performance factors, information transfer, and management issues.

2.0 Equipment*

During the file review phase of this Special Investigation, it was determined that equipment-related problems were found to be contributory in less than 10 per cent of the occurrences. However, during the field survey phase of the investigation, considerable feedback was received regarding a potentially worsening situation with respect to equipment adequacy. It is believed that many occurrences involving human performance factors may have been precipitated by equipment shortcomings; e.g., missed readback errors due to improperly fitting head-sets, misunderstood clearances due to frequency congestion, etc. Shortcomings in equipment then can lead to controller anxiety, stress, and fatigue.

It would appear that, in many ways, the current equipment capabilities are being stretched to their capacity. There are few maintenance spares for some key types of equipment, and, therefore, there is little growth potential in the ATC system as it is presently equipped. Significant replacement or modernization of many of today's deployed equipment systems is warranted.

2.1 Modernization

Transport Canada does have a coherent and ambitious equipment plan to ensure the safe and effective control of aircraft into the next century. The Canadian Airspace Systems Plan (CASP) contains a development and integration strategy for modernizing and improving the facilities and equipment used in the provision of air traffic services. The heart of Canada's ATC system modernization is the Canadian Automated Air Traffic System (CAATS) project. CAATS will provide extensive automation leading to the on-line acquisition, processing, display, and transfer of flight data. It incorporates extended use of automation in conflict prediction and resolution to permit increased control, capacity, and efficiency. Common controller work stations will be provided with common modular hardware and software, and air/ground data link will be provided for automatic two-way transfer of information (e.g., clearances, weather, etc.). The Minister of Transport announced the Government's decision to award the initial contract of $380 million for the first phase of CAATS in November 1989. However, the flight data processing systems and displays are not expected to be operational much before the end of 1996.

The ongoing Radar Modernization Project (RAMP) offers significant improvements for the processing of surveillance and weather data from radar sources. Related improvements to the Radar Data Processing System (RDPS) will include the capability to display hazardous weather, integrate radar data from different sources, provide conflict alerting, etc. While the first RAMP radar displays have been received, integrating all the related systems into the CAATS will likely take until 1996. In the meantime, increasing operational demands on the ATS system, coupled with increasing maintenance problems and a general lack of equipment capability for unforeseen down-time and/or system expansion, are straining current equipment capabilities to the fullest. Individual controller workload can be expected to increase further at busy centres, unless significant interim measures are taken to increase controller productivity.

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* Further background information on equipment-related problems is contained in chapter 4 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

While current plans in Transport Canada to upgrade equipment reflect a coherent and balanced appreciation of technological capabilities vis-à-vis projected operational demands, the implementation time frames leave the ATS system vulnerable to overload in the short-term. Therefore, the CASB recommends that:

> The Treasury Board ensure the provision of the resources required by Transport Canada to complete the Radar Modernization Project and the Canadian Automated Air Traffic System without delay.

CASB 90-01

Even with the timely implementation of the major CASP projects, currently deployed systems will require continuing attention to bridge the intervening period. Furthermore, there is a backlog of approximately 400 unsatisfactory condition reports and equipment change proposals; many of these have not been actioned because Transport Canada currently does not have the engineering capability to make the required operational improvements. Incremental improvements to the effectiveness and safety of the current ATC system can still be achieved. In some cases, off-the-shelf equipment may be available. The potential for attaining these improvements at relatively low cost should not be overlooked as the major Crown projects are implemented. Therefore the CASB recommends that:

> The Department of Transport pursue incremental improvements in equipment capabilities through enhancements to currently deployed systems.

CASB 90-02

2.2 Real-Time Surveillance on the North Atlantic

Notwithstanding the establishment of Minimum Navigation Performance Specification (MNPS) Airspace over the North Atlantic and notwithstanding the quality of on-board navigational equipment today, gross navigational errors continue to create serious losses of separation and sometimes risks of collision over the North Atlantic. Potential conflicts in the eastbound and westbound flows (of up to 300 aircraft each way each day) are identified using computers at Gander and Shanwick, respectively; furthermore, the flows are well organized on each side of the ocean under domestic radar coverage. However, once the aircraft depart coastal radar coverage, the current system is extremely vulnerable to non-recognition of conflict and non-detection of serious navigational errors. Nearly 17 per cent of the occurrences in the special database of this Special Investigation occurred over the North Atlantic in Canadian-controlled airspace.

Canada is working through the International Civil Aviation Organization (ICAO) on a special committee on Future Air Navigation Systems (FANS) in examining the necessary communications, navigation, and surveillance systems necessary for transoceanic travel. One such system is known as Automatic Dependent Surveillance (ADS), whereby aircraft will automatically transmit their positional data derived from on-board area navigation systems to ATC facilities via an air/ground data link. Controllers will then have the necessary surveillance system to monitor the flow of air traffic and detect potential conflict situations. Regrettably, such a real-time surveillance system appears to be years from operational implementation. However, Canada, as one of the nations providing ATC services over the North Atlantic is attempting to take a lead role in influencing the development and implementation of improved communication, navigation, and surveillance systems over the

North Atlantic. Toward this end, Transport Canada hosted an international meeting of the special committee on FANS in Ottawa in November 1989. Furthermore, Transport Canada is investigating tying current data link into the Northern Airspace Control System to facilitate development of ADS.

In view of the continuing frequency and magnitude of gross navigation errors involving large passenger-carrying aircraft over the North Atlantic Ocean, the CASB recommends that:

> The Department of Transport continue to urgently seek international cooperation through ICAO to implement a real-time surveillance capability over the North Atlantic.
>
> CASB 90-03

The CASB notes that there is a similar requirement for such real-time surveillance in the northern parts of Canada for the Montreal, Winnipeg, and Edmonton Flight Information Regions (FIRs). As surveillance systems for the North Atlantic are implemented, coverage should be extended into the Canadian Minimum Navigation Performance Specification Areas of the Northern and Arctic Control Areas.

2.3 Direct Controller/Pilot Communications (DCPC) Over the North Atlantic

The absence of real-time surveillance over the North Atlantic is exacerbated by the continuing inability of oceanic air traffic controllers to communicate directly with aircraft overflying the Atlantic. Today's communications rely upon high frequency (HF) radios requiring specialist radio operators as intermediaries between pilots and controllers. Although 16 minutes is considered to be normal, routinely 30 minutes is required to relay a simple message. With such delays in processing mandatory positions reports, it is difficult, if not impossible, for controllers to keep an up-to-date mental picture of the evolving air traffic situation. Ironically, some air carriers are beginning to install "sky phones" (a satellite-based commercial telephone system) to permit passengers the opportunity to communicate directly across the Atlantic in real time.

Such high quality voice communications systems are not now available for flight operations. However, several airlines, such as Air Canada, have equipped some of their aircraft with an Air Ground Communications System (AGCS) that provides a data link from shore-based facilities to the aircraft. In a joint Air Canada/Transport Canada experiment, some Air Canada aircraft are now receiving their IFR oceanic clearances automatically via this system; a hard copy of the clearance is actually delivered to the flight crew through the on-board data link printer, thereby obviating the need for oral communications. In the future, the use of satellites to permit both very high frequency (VHF) DCPC and expanded data link AGCS applications should further reduce current weaknesses in controller/pilot communications.

On 08 July 1987, an L1011 passed beneath the rear fuselage of a Boeing 747 with less than 100 feet vertical separation with both aircraft westbound at flight level 310 over the North Atlantic. While this occurrence was precipitated by a gross navigational error by the L1011, it could have been averted had ATC queried an error in the L1011 crew's estimated time of arrival over the next reporting point. Consequently, the CASB recommended that:

> The Department of Transport modify air traffic control procedures to ensure that any discrepancies of five minutes or more between pilot and ATC estimates on the North Atlantic be challenged *at once* to verify the estimate; and
>
> (CASB 88-03)

> The Department of Transport take immediate steps to provide more timely and reliable controller/pilot communications in the Gander Oceanic Control Area.
>
> (CASB 89-06)

Today's transoceanic communications problems are related to exclusive reliance upon an outmoded technology. In view of the continuing increase in transoceanic travel, the total unacceptability of HF communications for the timely control of air traffic, the absence of a real-time surveillance capability, and the quality of oral and/or data link air/ground communications technologically feasible through satellite-based systems today, the CASB recommends that:

> The Department of Transport seek international cooperation through ICAO to speed up the implementation of a satellite-based communications system to facilitate direct controller/pilot communications in the Organized Track Structure over the North Atlantic.
>
> CASB 90-04

Improvements in communication, navigation, and surveillance systems over the North Atlantic will undoubtedly be highly dependent upon satellite-based systems. It is the view of the CASB that the need is greatest for improvement in the communications and surveillance systems. Aircraft meeting Minimum Navigation Performance Specifications are technically capable of accurate transoceanic navigation. Therefore, in developing such satellite-based systems, priority should first be given to enhancing DCPC, perhaps coincident with providing real-time surveillance in oceanic control areas through the use of ADS Systems, before embarking on satellite-based navigation systems.

2.4 Technology Enhancements

While Transport Canada is undertaking a most ambitious, high technology approach to enhancing the ATS system, requiring highly complex systems integration, Transport Canada is also making use of relatively low-cost computerized systems to enhance controller productivity and safety. For example, the Northern Airspace Control System (NACS) is an automated system for non-radar control in Canada's far north by the Montreal, Winnipeg and Edmonton ACCs. Based upon pilot position reports, flight-planned tracks and speeds, and known upper level winds, this system computes projected aircraft estimates along the flight-planned track and gives the controller a coloured visual display. The algorithm used in the NACS does have a conflict prediction capability. The Gander Automated Air Traffic System (GAATS) calculates flight estimates for particular degrees of longitude taking into account the winds aloft. The computer algorithm does have the capability for predicting conflicts in traffic for eastbound traffic, and Transport Canada is developing a universal conflict prediction capability for the GAATS. The Gander Automated Message Processing System (GAMPS) is being developed to provide more direct communications between pilots

and controllers, by routing messages directly from the International Flight Service Station to the appropriate controllers.

Notwithstanding the foregoing, there is some evidence that full advantage is not being taken of the technological capabilities available today through such relatively low-cost computerized equipment. For example, the majority of occurrences in the Gander Oceanic Control Area involve westbound traffic, but GAATS does not yet have a westbound conflict prediction capability comparable to that available for eastbound traffic; nor does it possess a visual display analogous to the excellent colour presentation available on the NACS. Furthermore, GAATS will not be automatically updated, based on the position reporting to be passed through GAMPS.

In the area of training, there is a similar lack of application of available technologies. For example, at the ATS Training Centre, there is little reliance on computer-assisted learning for individual students. At the unit level, significant complaints were heard about the difficulties in introducing new materials to a large staff with irregular working hours; video presentations or computer-assisted learning modules could be of help in bridging such information gaps.

In view of the foregoing examples of available technologies and the need to improve controller productivity, the CASB recommends that:

> The Department of Transport accelerate the application of existing micro-computer-based systems.
>
> CASB 90-05

2.5 Airborne Collision Avoidance System

At the present time, Canada has not adopted a plan to implement some form of airborne collision avoidance system on large transport-category aircraft. In the United States, the Federal Aviation Administration (FAA) has adopted strong requirements for the implementation of a Traffic Alert and Collision Avoidance System (TCAS). Such equipment will be required on all commercial aircraft with more than 30 seats entering domestic United States airspace after 31 December 1993. Given the frequency and severity of loss of separation occurrences involving transport-category aircraft during IFR operations in Canada, some form of airborne collision avoidance system is required for Canadian flight operations. When the normal means for maintaining safe separation fail, flight crews on these aircraft must have the necessary information in order to initiate appropriate avoiding action. Therefore, the CASB recommends that:

> The Department of Transport promulgate operational requirements for the fitment of airborne collision avoidance systems on specified transport-category aircraft, with a target date for implementation of 31 December 1993.
>
> CASB 90-06

2.6 Control Tower Layout

Airport controllers in both Vancouver and Toronto towers were critical of the workspace layout in their units. At both airports, the evolution and addition of new equipment over the last 10 to 15 years have left consoles crowded and badly placed. At Toronto for example, the only source of Mode C altitude information, a slaved Cathode Ray Tube (CRT) display of the arrival radar display, is suspended from the ceiling between two airport controller positions. High ambient light and reflections have made this display impossible to see during the day shifts unless the controllers physically move from their operating positions. Several controllers complained of the constant need for "rubber necking" to read instrumentation, scan displays, and look outside the tower. In one Fact Finding Board report, it was noted that the controller had to move 15 feet from his work station to visually check the Airport Surface Detection Equipment (ASDE) display. The Confidential Aviation Safety Reporting Program has also received reports from tower controllers expressing concern over the location of the Operational Information Display System (OIDS) screen. Providing timely response to requests for information, while simultaneously monitoring aircraft activities, can pose serious problems for airport controllers.

In busy towers, the airport controller's workload is highly tactical in nature, requiring almost instantaneous decision-making. The current lack of integration of information requires tower controllers to monitor several displays and information sources to make critical decisions, such as the spacing between landing and departing aircraft under instrument meteorological conditions (IMC). It is understood that preliminary planning has been initiated by Transport Canada to improve the layout of the tower cabs at both Vancouver and Toronto.

In view of the inefficiencies in the layout of airport controller's information displays, the CASB recommends that:

> The Department of Transport accelerate the improvement of control tower layouts with a view to implementing an ergonomically efficient configuration.
>
> CASB 90-07

2.7 Indicator Modules (IMs)

The current IMs (the controllers' radar presentations) were introduced in 1978. Feedback was received at all four of the ACCs visited during this Special Investigation that a shortage of between one and four indicator modules (IMs) exists at each Centre. Further expansion of the ATS system will require the opening of additional control sectors of airspace, each radar sector requiring another IM. The Special Investigators were told that, being of older design, procurement of additional IMs is unlikely. Thus, future expansion of the number of sectors or the replacement of unserviceable units will be seriously hampered until the new equipment associated with the RAMP starts to come on-line. In view of the vulnerability of RAMP implementation to delays and in view of the limited expansion capability for the provision of IFR services in the short-term due to the non-availability of extra IMs in the Centres, the CASB recommends that:

The Department of Transport ensure the continued availability of high quality radar presentations for each sector in the busiest specialties employing radar separation criteria, pending the implementation of the RAMP equipment.

CASB 90-08

2.8 Frequency and Telephone Availability

Feedback was received at all four of the ACCs visited, expressing dissatisfaction with VHF frequency and telephone availability, in particular with respect to the shortage of backup VHF frequencies. (Transport Canada reports that, subsequent to this investigation, an Area Control Centre Emergency Communications System is being completed at all ACCs to provide controllers with an enhanced back-up capability.) Further, while the continuing addition of PeripherAL (PAL) frequencies is facilitating DCPC throughout much of Canada, controllers foresee continued requirements for more PAL stations. Insufficient frequency availability can lead to frequency congestion, which, in turn, can exacerbate the many forms of human error contributing to information transfer problems. For example, virtually non-stop voice communications by controllers can discourage pilots from seeking clarification of misunderstood clearances. Even with 14 HF frequencies available, the Gander Flight Service Station reports difficulty in coping with today's volume of traffic.

Dedicated telephone lines are also reportedly saturated in many cases, making it extremely difficult for timely coordination of information. For example, telephone communication between Gander, Edmonton, Montreal, and Reykjavik, Iceland was by one shared telephone line (653). With rising traffic levels, too many controllers were apparently trying to coordinate information on this single line. (Since the investigation Transport Canada has introduced a new line (403) to facilitate coordination between Montreal and Gander.)

One recent Transport Canada Fact Finding Board measured utilization rates during the hour preceding an occurrence and found a telephone utilization rate of 57.6 per cent and a radio frequency utilization rate of 74.2 per cent. Given the dependence of safe air traffic separation upon effective communications and coordination, such utilization rates can compromise the timeliness of communications.

Controller workload and anxiety could be decreased by reducing the frequent saturation of today's communication systems. Therefore, the CASB recommends that:

The Department of Transport provide additional radio frequencies and dedicated telephone lines where the level of current voice communications is impeding the timely transfer of information essential to safe flight.

CASB 90-09

2.9 Head-Sets

During the field survey, many controllers expressed dissatisfaction with their head-sets. Controllers are reportedly missing readbacks of clearances due to poor fitting head-sets. Apparently, many of the head-sets currently in use are not robust enough to stand up to repeated use and are not comfortable enough to be worn during a complete shift. Since the effectiveness of the information transfer process between controllers and between controllers

and pilots is so dependent upon quality aural reception, the disciplined wearing of a comfortable and reliable head-set is fundamental to safe ATC operating practices.

The difficulties in finding a head-set that will be acceptable to all users are recognized. Worn over long periods of time, even the most comfortable of gear can become a source of annoyance. In an effort to offer as much flexibility as possible, Transport Canada now offers controllers a choice of three modern technology head-sets. The performance of these head-sets and their reliability is being closely monitored by Transport Canada.

Given the susceptibility of oral communications to breakdowns due to human error and given the frequency with which communications-related factors are contributory to air traffic control occurrences, the CASB recommends that:

The Department of Transport ensure that:

a) each controller is provided with a personal head-set of his/her choice which is compatible with the system; and

CASB 90-10

b) each controller makes appropriate use of this head-set at all times when occupying a control position.

CASB 90-11

3.0 Staffing*

Based on this Special Investigation, the Board has determined that the most serious problem facing the ATC community today is the shortage of qualified controllers in most of the ACCs and in the Toronto Control Tower. The shortage seems to be the result of a combination of factors which unfolded in the early and mid 1980s.

The Resource Alignment Project (undertaken by Transport Canada in 1982) found that productivity gains and traffic declines had been such that the then current allocation of operating IFR controllers was approximately 150 Person Years (PYs) in excess of 1982 operational requirements. At about the same time, approximately 130 controller positions were found to be surplus when it was decided that supervisors must be qualified and available to perform controller duties. In Fiscal Year 83/84, an A-Base Review Team found an additional controller surplus, particularly in airport control towers, due in large part to a dramatic slowdown in the number of flights conducted under visual flight rules (VFR). In 1985, in accordance with the Government's policy to "downsize", a further 182 positions within ATS were earmarked for elimination, most of these being non-operational specialists.

It appears that Transport Canada over-reacted to the short-term traffic declines of the early 1980s and disregarded its own long-term forecasts (which had included "high-low" ranges in recognition of forecast uncertainties and short-term fluctuations). It was thus unprepared for the high traffic growth rates of the past five years, which resulted from economic recovery and the air carrier restructuring which occurred under economic regulatory reform.

To some extent, the Department of Transport appears to be placing an excessive reliance on technological gains to meet increasing operational demands, rather than pursuing parallel people-oriented programs for improving controller productivity. According to the Canadian Airspace Systems Plan:

> "Against a projected doubling in traffic growth by the year 2000, modernization of the ATC system, principally through the comprehensive use of automation provided by CAATS, will ensure little or no growth in the number of air traffic controllers, compared with the present growth rates without automation. However, the implementation of CAATS will result in a significant increase in productivity."

As of 01 December 1988, the ATS Branch had a total resource allocation for air traffic controllers of 1,924 PYs and had a controller strength of 1,831 personnel. At some units, such as Toronto and Gander, the staff shortages are more acute than the system-wide figures would indicate. In spite of the overall shortage within the ATS branch, several units are currently staffed above their allocated strength. Indeed, according to Transport Canada's most recent calculations, "six airports satisfied the benefit/cost criteria for airport control service discontinuance." Furthermore, with the exception of the "top 10" airports, air traffic at the other 50 towered airports collectively remains 9 per cent below the 1980 level, suggesting a less than optimal alignment of personnel resources.

* Further background information on staffing-related problems is contained in chapter 5 of the Staff Report on the CASB's Special Investigation into ATS Services in Canada.

In the past, staff attrition at ACCs was substantially overcome through voluntary transfer of controllers from the terminal control units or airport control towers. However, since the 1970s, it has been increasingly difficult to attract controllers from such sources to the busy ACCs. Several disincentives to transfer to the Toronto and Vancouver ACCs include increased work stress levels present at busy ACCs; high cost of living associated with the larger urban centres; and personal concerns over the potential failure to check-out, coupled with no guarantee of being able to return to their previous assignment in the event of failure. Notwithstanding existing financial incentives, appeals for volunteers to relocate are falling on deaf ears.

On 18 August 1989, the Minister of Transport announced a series of initiatives to deal with the increasing air traffic in the southern Ontario region. Among these initiatives were the continued recruitment of experienced air traffic controllers from other jurisdictions and expansion of the annual enrolment (from 216 to 312) in Transport Canada's Air Traffic Services Training Centre. This initiative has potential to provide some relief in the mid- to long-term; however, given the current lead-time necessary to fully train an ab initio controller candidate and the historic high attrition which occurs during training, significant alleviation of current staffing shortages is not expected for the short-term.

A significant number of controllers, supervisors, and managers interviewed during the field survey phase of the investigation were of the opinion that the situation may get much worse, before improvement is seen. They foresee increased controller attrition and an ageing controller population seeking early retirement. Transport Canada's 1988 Air Traffic Services Staffing Plan does not foresee recovery from the current staffing crisis until at least 1994; this forecast assumes no growth in baseline controller requirements beyond 1991. In other words, continued traffic growth into the 1990s and/or any slippage in the achievement of the expected productivity gains through increased automation will push this forecast get-well date even further into the future.

To cope with the staff shortage, Transport Canada relies heavily upon voluntary overtime and must implement traffic restrictions and flow controls on aircraft movements. From a safety point of view, staff shortages frequently result in single-controller sectors, sector consolidation, increased controller workload, fewer relief breaks and days of rest, etc. — all of which can have a detrimental impact on the safety margins of human performance. As already stated above, the file review of this Special Investigation noted staffing considerations in 94 (or 43 per cent of the 217) incidents analysed. (The impact of such staff shortages on workload and human performance are further discussed later in this report.)

Given current staffing problems, a new departmental approach is needed for more effective forecasting, recruiting, training, and resource allocation to provide sufficient air traffic controllers to meet current and anticipated operational demands. To this end, the CASB recommends that:

> The Treasury Board develop a program of additional financial incentives to attract qualified air traffic controllers to relocate to busier air traffic control units; and
>
> CASB 90-12

The Department of Transport reallocate some of the controllers from under-utilized airport towers to busier facilities.

CASB 90-13

To reduce the current financial disincentives for controllers to relocate to large urban centres, the CASB recommends that:

The Department of Transport study the feasibility of relocating Area Control Centres from large urban centres to areas with lower costs of living.

CASB 90-14

4.0 Workload*

The general view is that workload within the ATC system has risen dramatically in the past five years. Traffic growth has been significant, and it has been accompanied by considerable increases in traffic complexity. This increase in workload has not been accompanied by a corresponding increase in the number of air traffic controllers. Workload-related factors were identified in 35 of the 217 incidents examined during the file review of this Special Investigation, (i.e., 16 per cent).

To cope with this increased workload, additional sectors are kept open and are often staffed by a single controller (vs. the desired two or three persons). Indeed, staff shortages at some ATC units now mean that it is not always possible to have enough controllers on duty to staff the number of sectors requisite for the traffic volume and complexity. When this occurs, there remains little option but to close the sector by combining it with another. Flow control is also increasingly implemented in order to match workload with capability, particularly in the airspace around Toronto.

There is wide consensus among the controllers and in the literature that both IFR and airport controllers require a break after a work period of between one and a half and two hours in busy control positions. Longer periods of work, especially work involving concentrated and demanding effort, result in a rapid slowing down of the decision-making process, a distinct degradation of alertness, and difficulty in forming verbal messages. During periods of staff shortages for the open sectors, the capability to provide adequate relief and rest breaks is being compromised.

4.1 Overtime

Transport Canada's principal means for coping with periods of excessive workload is voluntary overtime. This has lead to a significant increase in the number of hours worked by individual controllers and a corresponding decrease in the number of their days off. In the eyes of many, overtime has become the glue that holds the ATC system together. There is a strong consensus among controllers, supervisors, and some managers that the situation is rapidly nearing safe limits.

Shift records were examined in both the Vancouver and Toronto ACCs. While the reliance on overtime varies by specialty or subunit, typically management is relying on at least one fifth of all shifts to be filled by a controller working overtime. Given the generous working arrangements for controllers (generally five days on and four days off), the total amount of overtime worked divided by the number of controllers available is not alarming. However, individual case histories differ dramatically from the averages.

Overtime shifts are allocated on a voluntary basis. Some controllers prefer to do little or no overtime. Supervisors and on-the-job instructors tend not to be available for overtime. Because of the financial incentives, a few controllers are seeking an excessive number of overtime shifts. The performance of controllers in this latter group is suspect from a safety perspective — especially over the long-term.

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* Further background information on workload-related problems is contained in chapter 5 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

Dependent on local work agreements, a controller typically is scheduled to work 17 or 18 shifts a month. A review of work records found that some controllers worked 25 to 28 shifts in a 30-day period. Indeed, the Investigators heard of one controller who had worked 31 shifts during the month of May 1989. Yet, the average number of shifts (regular and overtime) worked by all controllers may have only been 21 under such circumstances.

As a result of remuneration provisions for overtime in the collective agreement, there is considerable financial incentive for controllers to work multiple, consecutive days of overtime. Originally designed to be a disincentive to management to rely on overtime, the remuneration provisions become a strong incentive for controllers desiring to substantially increase their income. After working two days of overtime, controllers receive 2.5 times their normal salary for the third and subsequent days of overtime worked. Cases have been reported where controllers are working five, six, or even seven overtime shifts during their four days off. Some controllers are not volunteering for an overtime shift or two for fear of upsetting a colleague's run on overtime at 2.5 times the normal pay rate. Indeed, there was anecdotal evidence that some controllers are collaborating to manipulate the shift schedule so as to maximize the financial gain for individual controllers.

According to the collective agreement, controllers must be granted a paid day off after working nine straight days. Yet, the review of work records revealed isolated cases where individuals had worked far in excess of the prescribed limit — apparently without expressed disquiet by either Transport Canada management or CATCA.

Excessive reliance on overtime presents serious potential for controller fatigue and may exacerbate the current staffing shortage through increased sick leave and, ultimately, increased controller attrition. To achieve a safer and more equitable distribution of the workload, the CASB recommends that:

> The Department of Transport set a limit on the number of work shifts permissible in a nine-day cycle, the minimum number of days off between shift cycles, and the maximum number of hours worked in any 24-hour period.
>
> CASB 90-15

In view of the current staff shortages and the possible lead-times required to achieve the foregoing changes, further action is required to discourage the current inequitable distribution of overtime. Therefore, the CASB recommends that:

> The Treasury Board immediately take steps to remove the financial incentive to work excessive multiple shifts of overtime on consecutive days.
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> CASB 90-16

5.0 Training*

The objective of the ATS training program is to "develop, maintain, and improve, on a continuing basis, during the career of each individual, the technical skills and proficiency required by the ATS Branch." While current training concerns are focusing on training for initial qualification and licensing, training must be considered in the context of a full career. Current controller shortages are in part attributable to a freeze on training in 1982 and delays in reopening ab initio training in the mid-1980s — even though staff shortages were by then being forecast by ATC management.

5.1 Training Production

Policies and procedures for the recruitment and selection of prospective air traffic controllers are developed at the national level. The actual responsibility for controller recruitment and selection has been delegated to Regional Managers for ATS and General Managers of the ACCs. Each region is allocated a specific number of basic training positions at the ATS Training Centre at the Transport Canada Training Institute (TCTI) on an annual basis. The Investigation Team was told of significant delays between the actual regional selection of controller candidates and their assignment to a class at TCTI; apparently, delays of six months to a year are not unusual in placing selected candidates. Many personnel interviewed believe that the candidates with the most initiative and qualifications are capable of finding attractive alternative employment during such lengthy delays. Transport Canada recognizes this problem.

The training process itself is long and arduous. Once training commences, typically a controller can expect to spend between 15 and 30 months in basic training and unit qualification training before being licensed as a qualified air traffic controller. Because of the current critical staff shortages, Transport Canada is exploring several initiatives to reduce the time spent to achieve an initial qualification status. Current plans include shortening of the basic ATC course by streaming candidates to either IFR or VFR control duties. These changes will permit increasing the annual intake of the training system from the current 216 to 312, with the hope for a corresponding increase in output.

To a large extent, current training is limited by the capability of operational units to conduct on-the-job training (OJT). To qualify at an operational unit, new controller candidates have been required to demonstrate proficiency in all positions of the subunit to which they have been assigned. Thus, it has not been unusual for a controller candidate to spend a year at an operational unit before fully qualifying as a licensed air traffic controller.

In the past, some controllers received an educational base for a full career in ATC through community college programs. These trial programs were terminated in the early 1980s. While such programs could not provide relief for the short-term needs of the ATS system, for the longer term, community college programs conceivably could obviate the need for basic training at a national training centre. It is understood that Transport Canada is again considering the merits of such programs, as well as the possibility of initiating controller training through the private sector.

* Further background information on training-related problems is contained in chapter 6 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

In view of the growing gap between operational demands and the availability of qualified air traffic controllers, training production must urgently be increased to ensure a continued satisfactory margin of safety in the provision of air traffic services. New initiatives will be required. The CASB recommends that:

> The Department of Transport speed up the entry of the best controller candidates recruited, directly into the ATS training system.
>
> CASB 90-17

> The Department of Transport adopt the concept of specialization during basic training for the VFR and IFR concentrations.
>
> CASB 90-18

> The Department of Transport restructure qualification training at the unit level, through further specialization in particular sectors of a specialty if necessary, to prepare trainees for operational duties within six months of assignment to the operational unit.
>
> CASB 90-19

> The Department of Transport find alternate means to provide the necessary educational basis for a full career in air traffic control through private sector or community college programs.
>
> CASB 90-20

5.2 Attrition

Production of sufficient numbers of qualified controllers has been compromised by continuing high attrition during training. Since June 1987, just under 50 per cent of students who commenced basic training at TCTI have successfully completed the course. Success rates in qualification training differ greatly between airport control towers and IFR units. Over the past years, there has been a steady increase in the requirement for direct-entry of IFR candidates at ACCs. Attrition rates among these direct-entry IFR candidates are substantially higher than those for new controllers who initially assume VFR control positions. At control towers, success rates are approximately 80 per cent; at IFR units success rates are about 20 per cent. There has been no significant change in these rates for at least 20 years.

During the field survey, Investigators received comment that controller recruiting and selection processes could be more effective; in the opinion of some, good candidates were being unnecessarily screened out. Because ATC is a complex activity, it has been difficult to devise effective selection procedures; the attributes and characteristics of a successful controller are still being debated. Transport Canada has continued to review its selection criteria and screening processes over the past year.

The Investigators also received frequent comment that good candidates are unnecessarily being screened out of the system through the training process. For example, current duty assignment practices do not take into account the strengths and weaknesses demonstrated by individual students during basic training; rather duty assignments are made prior to

commencement of the basic training phase. Hence, students with strong VFR aptitudes may wash-out in training during the difficult IFR phase, or students with the necessary aptitudes but who have demonstrated a slower learning rate may be inappropriately assigned to a most demanding operational unit. Better use of student strengths, as demonstrated in the basic training phase, offers the potential for a significant reduction in student attrition during qualification training.

The Investigators frequently heard the view that the system expects too much of new controllers and that they need to be eased into the system more slowly. Ab initio candidates today are frequently assigned positions at busy ACCs where they are expected to perform at or near the top of the operating controller levels. There are few, if any, occupations outside of ATC which expect such rapid advancement. Undoubtedly, such demands contribute substantially to high attrition during qualification training.

An apprenticeship training program would permit controllers to be trained at their individual learning rates in progressive steps. Competency would increase gradually, and individuals would be permitted to build upon experience gained as an operational controller. Through an apprenticeship program, the focus would be on training and developing successful candidates to meet the prescribed standards, rather than eliminating those who fail to perform at the highest levels of controller competency — before even being granted a licence! In other words, the fundamental training philosophy of the ATS system needs to emphasize student development rather than further selection. Transport Canada reached an agreement with the employee association in December 1989 for the development of an apprenticeship-type training program. Such efforts are to be encouraged.

Until recently, controllers in training who failed to check out upon completion of qualification training were released from the employ of Transport Canada. Candidates who were unable to qualify at what are considered to be the most difficult units (e.g., direct-entry IFR at Toronto ACC) may well have been able to qualify for less demanding positions. Indeed, as noted above, attrition rates among direct-entry IFR candidates have historically been much higher than those for controllers who initially assume VFR control positions. After several years of experience within the system, individuals who have had difficulty in qualifying at the toughest operational units may be able to qualify where they had previously been unsuccessful. However, until recently, they were lost forever to the ATC system — most after a significant investment in training. Recycling of unsuccessful candidates to less demanding units would seem to be a more effective and efficient use of all available resources. Transport Canada reports that initiatives in this direction have begun.

Since continuing high attrition in training is delaying recovery from the current controller shortages, the CASB recommends that:

> The Department of Transport validate, and modify if necessary, its selection criteria and screening processes to absorb most training attrition during basic training.
>
> CASB 90-21

> The Department of Transport, when assigning controller candidates to operational units, consider the individual's performance during basic training.
>
> CASB 90-22

The Department of Transport implement its apprenticeship-type training program as soon as possible to develop air traffic controllers by assigning them progressively more demanding operational duties.

CASB 90-23

5.3 Instructor Availability

Transport Canada is experiencing difficulties in attracting a sufficient number of qualified candidates for instructional positions at its ATS Training Centre and for on-the-job instructor (OJI) positions in operational units. The Training Centre is in stiff competition from operational units for the best people; as of July 1989, the Training Centre was operating with six fewer instructors than their established need. Because the Training Centre is not a formal part of the ATS Branch and because Training Centre controllers do not maintain operational proficiency, instructors at the Centre can become isolated from the mainstream of their career development. (The longer they have been away from operational duties, the more likely that their instruction is vulnerable to currency and relevancy problems — thereby further isolating them from their operational colleagues.)

In the Regional schools at the ACCs, instructors normally forfeit the opportunity for significant financial remuneration from working overtime as an active controller in the ACC. As instructors, they also must accept responsibility for the actions of their students. Within the operational units, OJIs increasingly find that the current supplement (of $2.50 per hour) is not worth the added responsibility of "putting one's licence on the line everyday." The OJI is faced daily with the task of balancing the maximization of training value with the maintenance of safe operating standards in the real world.

Success rates in training and the overall quality of ATC services provided is critically dependent upon the quality of instruction received during training. Therefore, the CASB recommends that:

The Department of Transport develop incentives to attract experienced, operational controllers to periodically assume instructional duties at the ATS Training Centre, in the Regional schools, and as on-the-job instructors.

CASB 90-24

5.4 Instructor Training

Instructors selected for duties at the ATS Training Centre receive a three and a half week instructors' course before assuming instructional responsibilities. Controllers selected for OJI duties are required to attend locally conducted seminars on training techniques; however, current staff shortages are precluding some OJIs from completing the seminar program. In view of the extremely high attrition rates sometimes being experienced at the ACCs and to develop the pedagogical skills necessary to help the trainees attain their maximum potential, the CASB recommends that:

The Department of Transport devote increased attention to providing formal instruction for the qualification of on-the-job instructors.

CASB 90-25

5.5 Simulation

The use of simulation in ATC training is lagging significantly behind current technology and contrasts unfavourably with the increased use of simulation as an effective training tool found in other segments of the aviation industry. According to the Canadian Airspace Systems Plan (1988):

> "Recent studies have shown that the cost per successful trainee is inordinately high. More effective training systems capable of accurately simulating the ATC environment have been identified as a means of reducing controller training cost."

The ATS Training Centre utilizes an IFR simulator (vintage 1974) which has significant differences from the actual IFR system currently in use in the ACCs; i.e., the Joint Enroute Terminal System (JETS). Simulators at the regional training schools have even less capability than those found at the Training Centre.

Transport Canada has initiated a National Air Traffic Control Simulator (NATS) Program with the goal of providing the tools necessary not only to train novice controllers but also to permit periodic evaluation of controller proficiency.

Given current staff shortages and high wastage rates during training, simulation offers considerable potential for improving training effectiveness. Therefore, the CASB recommends that:

> The Department of Transport accelerate development and implementation of full-mission and part-task simulators for use in basic, qualification, and recurrency training.

CASB 90-26

5.6 Refresher Training

All operational controllers are required to undergo refresher training each year. However, over the last several years, staff shortages have resulted in many controllers not receiving the required refresher training. At best, managers have only been able to approve an average of two or three days of refresher training a year, all of which is done on overtime.

On a day-to-day basis, controllers use a portion of all the separation criteria and techniques available to them. Yet they must keep their skills sharp to cope with any unusual operating circumstances. For example, radar controllers must be capable of providing procedural separation in the event of radar failure. In view of the need to maintain currency on all required control techniques applicable to the specialty or subunit, the CASB recommends that:

The Department of Transport revitalize the refresher training program to assist operational controllers in meeting the standards prescribed in MANOPS.

CASB 90-27

6.0 Supervision*

As in most team endeavours, it is the first-line supervisors who set the operational tone which determines the effectiveness of team performance. The first-line supervisors are principally responsible for assuring the day-to-day quality in the air traffic control services provided by their subunits. Yet, there was overwhelming consensus among those interviewed during the field survey phase of this Special Investigation that first-line supervision at many units is, at best inadequate, and at worst non-existent. Apparently, many supervisors are spending up to 90 per cent of their time at control positions within the subunit and are therefore unable to perform the traffic management, workload balancing, quality assurance and overseeing functions.

A difference of opinion exists between personnel at operational units and those at Transport Canada Headquarters regarding working supervisors. Operational unit personnel believe that staff shortages are creating the need for supervisors to work control positions. ATS Headquarters management are of the opinion that excessive supervisor "on sector time" is for the most part "elective" and is not a system requirement.

Ironically, during high traffic periods when supervision is most needed, supervisors are least available to fulfil the supervisory function. In part, this is attributable to Transport Canada's operating philosophy that the supervisor should be the last person called in to control during peak periods and the first controller to back out of a control position when the workload begins to subside.

The supervisor was found to be working a control position in 72 of 217 (or 33 per cent of) loss of separation occurrences examined in the file review of this Special Investigation. Following a serious loss of separation occurrence at Toronto on 06 November 1988 when designated tower supervisors were working control positions, the CASB recommended that:

> The Department of Transport take immediate steps to ensure that designated controllers are maintaining an operational overview of the evolving air and ground traffic situation in each of the Toronto ATS units during busy traffic periods.
>
> CASB 88-18

The Department of Transport has responded favourably to this recommendation by increasing the supervisory complement at the Toronto ACC to permit dual supervisory coverage in all specialties during an eight-hour period when traffic is heavy. In addition, Transport Canada is planning to extend this operational overview capability during high traffic periods in all ACCs and major towers. Due to current staff shortages and the difficulties in attracting qualified controllers at some units to become supervisors, any real increase in the number of supervisory staff available may be some time away.

Nevertheless, in view of the importance of the supervisor in ensuring an equitable distribution of workload, maintaining the requisite levels of operational standards and discipline within the specialty, as well as maintaining an operational overview and coordinating the necessary strategic planning to cope with all contingencies, a fundamental

* Further background information on supervision-related problems is contained in chapter 7 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

change in the role of the supervisor must be adopted immediately. For example, establishing a maximum percentage during any one shift permissible in a control position and limiting a supervisor from controlling above a specified Pace Level might ensure a more effective supervisory presence. Therefore, the CASB recommends that:

> The Department of Transport establish and enforce operational restrictions on supervisors performing in a direct control position.
>
> CASB 90-28

6.1 Incentives to Supervise

Among controllers there has been a perceived degradation in the role of the first-line supervisor; consequently, many controllers do not aspire to become supervisors. They question the wisdom of taking on additional responsibilities for little or no personal advantage; e.g., the financial incentive is less than $2,000 per year, and there is less opportunity to work overtime. Other controllers expressed the view that, under the current circumstances, supervisors have an unusually heavy workload and associated responsibilities and are often placed in positions where their licence is "on-the-line"; yet they perceive that they receive little support from management and are not respected by working controllers. In one centre, six supervisors have recently chosen to leave the supervisory ranks.

In order to attract the most suitable controllers to the supervisory role, the CASB recommends that:

> The Department of Transport develop and implement a program to enhance the status of operational supervisory personnel, including monetary or other incentives, if necessary.
>
> CASB 90-29

6.2 Training for Supervisors

While the first-line supervisor is currently faced with a very difficult task, little or no formal preparation is provided for first-line supervisors. More often than not, operational controllers advance to supervisory positions without any specific training on how to be an effective supervisor. Since the effectiveness of an ATC team is directly influenced by the quality of supervision, the CASB recommends that:

> The Department of Transport immediately develop and implement a dedicated training program on the principles of supervision for all controllers being prepared for operational supervisory responsibilities.
>
> CASB 90-30

6.3 Quality Control

Concerns over the effects of inadequate supervision extend into the conduct of quality control programs. To help identify weaknesses in the performance of individual controllers, several quality control programs are conducted at the unit level, normally annually; (e.g., a

knowledge verification test, a phraseology improvement program, over-the-shoulder evaluations, etc.). However, since supervisors are often spending the majority of their time in operational control positions, many are not available to carry through these quality control programs. Furthermore, there was some evidence received that the content itself of some of these programs had lost its relevance and impact over time; consequently, even when implemented, the effect was often perfunctory only.

Like refresher training, a realistic program of continuing evaluation of the individual's performance is required to ensure that each controller is maintaining his/her skills and knowledge and is applying them in accordance with the requisite standards.

Therefore the CASB recommends that:

> The Department of Transport improve performance evaluation for operational controllers to ensure that standards are consistently applied.
>
> CASB 90-31

7.0 Operating Procedures*

In recent years, there has been a continuing evolution in ATC operating procedures. Increased traffic levels and complexity, coupled with changing aircraft performance capabilities, have necessitated these changes. Frequently, changes have been introduced to rectify shortcomings identified through the investigation of ATS operating irregularities. With procedures in such a state of flux, there is a widespread perception among controllers that there is excessive procedural change. Nevertheless, the Investigation found that Transport Canada has a rational and coherent system for the development of new operating procedures, including validation of significant procedural changes through operational simulations at the ATS Research and Experimentation Centre in Hull, Quebec.

As traffic increases and the ATS system becomes stretched, adherence to established procedures becomes critical to safe operations. While this need is widely recognized, some controllers are cutting corners on occasions, trying too hard to get the job done or to provide a level of service for which they are not capable. Many controllers interviewed attributed non-compliance errors (or non-standard application of procedures) to the lack of supervision in the subunits; as one controller stated: "different controllers, different crews, different supervisors equal different application."

Of the 217 occurrence files reviewed in detail during this Special Investigation, procedures-related problems were noted in 52 files; i.e., approximately 25 per cent of occurrences.

7.1 Introduction of New Procedures

There are significant shortcomings in the current methods used to introduce procedural changes. When a particular procedure has served controllers well for 15 or 20 years, there is natural resistance to changing it which must be overcome. When significant changes are introduced, they must be available with sufficient lead time and in both official languages in order to properly disseminate the information and to permit its discussion and assimilation by controllers — before the effective date of implementation. Furthermore, for complex procedural changes, "hands-on" familiarity in a simulator or introduction to the new procedures under light to moderate traffic conditions may be advisable. Items requiring mandatory briefings warrant standardized presentations of a consistently high quality, so as to bring all controllers quickly up to a point where they can safely implement the new procedures. The use of computer-assisted learning and/or video packages could help in this regard.

In view of the importance of the consistent implementation of standardized operating procedures to the safe separation of flights, the CASB recommends that:

> The Department of Transport revise its current processes for the implementation of new procedures to ensure adequate controller familiarity by providing:
>
> — necessary lead-time;

* Further background information on procedures-related problems is contained in chapter 8 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

— consistency and quality of mandatory briefings; and

— an opportunity for controllers to practise complex new procedures under low workload, if necessary.

CASB 90-32

7.2 Transfer of Control

One area of concern that frequently arose during the field survey phase concerned the transfer of control from the IFR arrival controller to a tower controller under visual meteorological conditions (VMC). It is quite common that, once an airport controller has sighted an IFR arrival, control of that aircraft is transferred to the airport controller. Visual separation criteria rather than instrument separation criteria are then applicable. This greatly assists in the expeditious flow of traffic. However, there appears to be considerable confusion among VFR and IFR controllers as to the correct procedures to be followed — particularly under IMC when there is a transfer of communications but no transfer of control responsibilities.

In view of the apparent different interpretations by controllers as to the correct procedures to be followed for the transfer of control from terminal to tower controllers, the CASB recommends that:

> The Department of Transport provide clarification to controllers regarding the criteria, procedures, and consequences for the transfer of control of IFR arrivals from a terminal controller to a tower controller under instrument meteorological conditions.

CASB 90-33

7.3 VFR/IFR Mix

With increasing air traffic volumes, mixing VFR and IFR traffic in high density areas is becoming increasingly difficult. Human performance limitations are the limiting factor and underly the shortcomings in the traditional precept of "see and be seen." Recognizing that the airspace around Toronto and Vancouver is being used to its capacity during peak periods, the Department of Transport is attempting to introduce legislation that would require aircraft to be fitted with automatic pressure altitude reporting equipment, responding to Mode C interrogations in this airspace. This equipment would simplify air traffic control and flight procedures by permitting controllers to identify aircraft found in the proximity of another aircraft and to determine the altitude at which it is flying. The equipment permits an automatic exchange of information, thus reducing the volume of information required verbally between pilots and controllers. These changes, which require an amendment to Air Navigation Order (ANO) Series II Number 10, have not yet been put into effect.

Although VFR traffic has been essentially eliminated at Lester B. Pearson International Airport, approximately one-half of the traffic in the Vancouver area operates under VFR. Conflicts between VFR and arriving IFR aircraft in the Vancouver area remain common. Several controllers expressed concern over the adequacy of the current system of 10 entry points into the Terminal Control Area. Controllers also expressed the view that, notwithstanding their best efforts, they are currently unable to adequately provide VFR

traffic information to IFR aircraft. (This situation has undoubtedly been aggravated by the absence of a Mode C altitude reporting requirement.) Furthermore, many aircraft operating under VFR in Class D airspace, just outside of the Vancouver Terminal Control Area, are not required to communicate with an ATC unit. The Canadian Airspace Review (undertaken by Transport Canada in 1985) made several recommendations for improving control of VFR traffic operating near major airports. These recommendations have not yet been fully implemented.

On 01 December 1989, the Transponder and Automatic Pressure Altitude Reporting Equipment Order (ANO Series II No. 10) was amended. Aircraft operating in the airspace surrounding Toronto and Vancouver must now be equipped with automatic pressure altitude reporting equipment responding to Mode C interrogations. This equipment will simplify air traffic control by reducing the volume of information which must be exchanged between pilots and controllers.

In view of the continuing hazard to flight created by the mix of VFR and IFR traffic in and around major Canadian airports, particularly at Vancouver, the CASB recommends that:

> The Department of Transport re-evaluate the adequacy of the current Class C airspace dimensions and designated entry points for the Vancouver Terminal Control Area.
>
> CASB 90-34

7.4 Opening and Closing of Sectors

During the field survey, considerable feedback was received with respect to perceived inadequacies in existing procedures for the opening and closing of sectors. Considerable judgement is required with respect to the timing of sector opening and closing. Such judgement is totally dependent upon effective supervision. However, as pointed out earlier, there are serious shortcomings in the availability and quality of supervision available to operational controllers today.

During this Special Investigation, problems were noted with respect to timely decisions regarding the opening of sectors, the availability of qualified personnel to man a new sector when required, the adequacy of sector briefings upon opening or collapsing a sector, etc. Inter-controller coordination requirements are particularly acute during sector briefings when a relieving controller assumes a position or when a sector is opened or closed. (Of the 370 Fact Finding Board reports in the database, 17 cases of inadequate sector briefings were recorded.)

In view of the vulnerability of the ATC system to human errors during opening, combining, or closing sectors, and given current and expected staff shortages, the CASB recommends that:

> The Department of Transport prescribe operating guidelines for the timing, staffing, and transfer of responsibilities for opening and closing sectors.
>
> CASB 90-35

8.0 Human Performance Factors*

By far the most common contributory factors in ATS incidents were those that involved the human part of the system. Of the 217 incidents studied in the file review, contributory human factors were identified in a 182 or 88 per cent of the occurrences. These included problems in planning, judgement, inattention, workload, forgetfulness, distraction, information transfer, etc. Hence, maintenance of the required safety standards will require an improved understanding of the human element of the ATS system so as to be able to shape a working environment and procedures which are more tolerant of any shortcomings in human performance. To this end, Transport Canada is to be encouraged in its planning to co-host a major international symposium on the factors affecting human performance in ATC in the fall of 1990.

8.1 Vigilance

Inattention, forgetfulness, lack of vigilance, or whatever name one chooses to call it, appears to be contributory in approximately 50 per cent of all ATS occurrences. Human reliability in performing tasks which require constant attention is poor. Since the number of actual midair collisions is still extremely small, the various redundancies built into the system are generally adequate to compensate for this shortfall. However, the designers and operators of the ATC system must seek the highest possible reliability; i.e., the lowest possible human error rate.

There is a paradox in that ATC occurrences often happen during periods of light, non-complex traffic. Indeed, nearly 75 per cent of the inattention errors analysed during the file review occurred under relatively low workload/complexity situations (i.e., at Pace Level Four or below).

Research conducted on behalf of the FAA in the U.S.A. has shown that vigilance tasks are stressful. People feel less attentive and more fatigued, irritated and strained after doing a vigilance task than they were before — irrespective of personality type. Furthermore, older test subjects have demonstrated greater performance decrements over two-hour test sessions in vigilance tasks requiring visual scanning than younger test subjects. Given the age distribution of the current Canadian air traffic controller population, vigilance-related occurrences can be expected to continue at a disproportionately high rate.

Closely related to the problem of vigilance is distraction. Of the 217 occurrences of the file review, 22 cases of distraction were noted. The multiple tasks of the controller (i.e., monitoring, communications, flight data preparation, interaction with the computer, etc.) are all highly vulnerable to distraction.

Complacency and boredom may also contribute to the frequency of attention-related occurrences. For example, sustaining a sharp, critical mind is extremely difficult for an oceanic controller whose job is essentially one of monitoring the progress reports of as many as 40 to 50 aircraft on paper strips as these aircraft transit for several hours under the controller's surveillance. Several suggestions have been offered for minimizing the hazards

* Further background information on human performance factors in ATC is contained in chapter 9 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

of inattention or vigilance-related occurrences. It is believed that full-time active supervision helps maintain the necessary controller discipline essential to good vigilance and that well-rested controllers are less likely to make errors resulting from inadequate vigilance. Since psychologists have found that the human being is inherently badly suited for the monitoring function; automated systems can be adapted to monitor human performance and render alerts when appropriate. The conflict alerting capability planned for the Canadian Automated Air Traffic System might help alert an inattentive controller to a developing conflict situation.

In its report on a Special Investigation into the Risk of Collisions Involving Aircraft On or Near the Ground (issued in August 1987), the CASB recommended that:

> The Department of Transport initiate a multi-disciplinary study on the most effective means for sustaining vigilance, particularly for air traffic controllers under periods of low activity rates.
>
> CASB 87-41

As of 05 September 1989, Transport Canada was still only planning to "take action to determine the methodology and personnel requirements to conduct an analysis of means of sustaining vigilance." In view of the frequency and potential consequences of controller inattention, research, such as that sought through CASB Recommendation 87-41, is required to determine more effective means for sustaining controller vigilance. In addition, the CASB recommends that:

> The Department of Transport accelerate all technical initiatives with a potential for providing controllers with automated conflict prediction and alerting.
>
> CASB 90-36

8.2 Fatigue

Typically, a controller's shiftwork cycle is highly disruptive to natural body rhythms. Continuously working a cycle of two days, two evenings, and a midnight shift can have the effect of throwing the body into a constant state of internal disarray. It is believed that, just as eastbound flights have the most adverse effects on long-distance pilots, quick changes in shift patterns (i.e., only eight hours off between shifts) are most disruptive to controllers' natural body cycles. Research has demonstrated that the human being is fairly tolerant of changing workshifts but is less tolerant of changing sleep cycles. Indeed, some controllers spoke of difficulties in getting to sleep following a midnight shift — regardless of how tired they felt.

The need for regulating controllers' work and rest periods has long been recognized. Indeed, the current work cycle of Canadian air traffic controllers (generally 5 days on, 4 days off) inherently compensates for the disruptive effects of the rotating shift schedule during the five-day period. The collective agreement does make provision for a generous amount of time-off for controllers. If the four days off are days of rest, then the detrimental effects of shiftwork are minimized. However, if a controller works during what is supposed to be a period of recuperation, there is cause for concern.

As discussed earlier, management must put extensive reliance on the use of overtime to make the ATS system operate today. There was almost universal concern expressed by the controllers that excessive overtime is an inappropriate use of time-off and only exacerbates the naturally fatiguing effects of shiftwork.

While analysis of the ATS incidents shows a decline in the frequency of occurrences compared to the number of days worked, no conclusion can be drawn in the absence of normative data. There has been no systematic analysis of data for controllers working in excess of six consecutive days either in Canada or abroad. The controllers interviewed believe that the current pace of life induced by overtime requirements can not be safely maintained and that mistakes are being made. In spite of the very lucrative nature of today's overtime routine, the controllers strongly expressed the view that further restrictions on controller working hours are required.

Unfortunately, the assessment of fatigue is very subjective by nature. It is difficult to accurately and consistently measure. Therefore, there is often insufficient evidence to assign fatigue as a causal or contributory factor to an ATS occurrence. Nevertheless, there is general agreement on the effects of fatigue on human performance; e.g., reduced attention span and ability to concentrate, indecision, inability to formulate simple verbal messages, etc. While some of these effects can more easily be measured than others, there has been little or no research in Canada as to how they pertain to air traffic controllers.

Given the frequency of inattention errors, decision-making errors, information transfer and coordination problems, etc.; given the naturally fatiguing effects of a rotating shift cycle; and given the exacerbating effects of the current workload and overtime situation, further restrictions on the work-rest cycles are required. In addition to the restrictions recommended in CASB 90-15, the CASB recommends that:

> The Department of Transport make and enforce further restrictions on:
>
> — the maximum number of hours which can be worked at a particular control position without a relief break; and
>
> — the minimum number of rest hours between shifts; and
>
> CASB 90-37

> The Department of Transport, in cooperation with the Department of Health and Welfare and international authorities, initiate a program of research into the adverse effects of circadian disrhythmia and sleep deficits on air traffic controllers' job performance; and
>
> CASB 90-38

> The Department of Transport initiate research into the effects of regularly working overtime shifts during normal days of rest on individual controller's job performance.
>
> CASB 90-39

8.3 Aeromedical Considerations

Studies done during recent years have concluded that stress has been accorded a much greater influence in ATC than can be substantiated. The interviews of this investigation's field survey suggest that the challenge of dealing with heavy and complex traffic is one of the major satisfiers for a controller. While life's more mundane stressors, such as family problems, probably exist in the same amount as in any other occupation, these stressors seem to be magnified by the requirements of shiftwork and extensive overtime requirements. There is also some evidence that many controllers are experiencing morale problems — generally related to current employee/ management relations and the current working situation.

A major research project conducted by the FAA examined air traffic controllers' psycho-physiologic and patho-physiologic responses to work. The study found that the test population of controllers was found to have an increased incidence of hypertension compared to findings in other such studies, regardless of the criteria applied. Controllers experienced 2.5 acute health change episodes each year, resulting in significant numbers of lost days from work. Some controllers experienced a slightly increased risk of developing peptic ulcers. Half of the controllers examined in the research were diagnosed as having at least one psychiatric problem, the most prevalent being a disturbance of impulse control. Thirty-five of the controllers examined in the study developed "burnout", defined as a syndrome that includes a generalized anxiety about work, accompanied by a dread of going to work. While no objective physical findings characterize these controllers, they all experienced a deep belief in the phenomenon, suggesting the possibility of a self-fulfilling prophecy. If these findings have application in Canada, they could have important consequences given the rising average age level of Canadian air traffic controllers.

Transport Canada has endeavoured to meet air traffic controllers' aeromedical requirements through the Air Traffic Control Occupational Health Program (ATCOH). Medical doctors, nurses, and psychologists are available on a part-time basis to provide counselling to those who request it. Interviews with ATCOH staff indicate that there has been a steady increase in stress-related complaints, usually the result of excessive overtime. A typical patient has been controlling traffic for 20 years, feels tired but can't get to sleep, is working too much overtime but likes or needs the money, has no other activities and therefore lacks balance in his life.

In view of the importance of individual health and well-being to the long-term effectiveness of the controller workforce, the CASB recommends that:

> The Department of Transport initiate a major lifestyle modification program for air traffic controllers through its Air Traffic Controllers' Occupational Health Program.
>
> CASB 90-40

8.4 Visual Perception

In at least 9 per cent of the reported occurrences involving IFR aircraft in the database of this Investigation, one of the aircraft was operating under VFR. Typically, either a large aircraft on an IFR approach came into conflict with a light VFR aircraft just outside Class C airspace, or an IFR aircraft cleared for a visual approach came into conflict with other IFR traffic cleared for a visual approach or with VFR traffic. In both of these cases, the primary

responsibility for collision avoidance rests with the pilots using the "see and be seen" principle.

For a number of reasons, the "see and be seen" principle is not working well around major airports; for example:

— IFR pilots' assumption that radar separation is being provided from all other traffic including VFR traffic;

— Controllers' over-reliance on secondary radar digital data tags for the identification of small aircraft;

— Controllers' assumptions that non-Mode C returns in the control area extensions represent aircraft operating below the floor of Class C airspace;

— Increasing procedural complexity and cockpit automation, resulting in reduced look-out and increased pilot pre-occupations within the cockpit;

— Generally higher approach speeds of IFR aircraft, resulting in reduced time available for conflict recognition and evasive manoeuvres; and,

— Increasing traffic densities, placing pressures on controllers and pilots to adopt visual approaches to expedite traffic.

Given all the natural limitations of the human eye, in busy terminal areas, extra measures are required to assist pilots. Mode C altitude reporting transponders, VFR corridors, airspace classifications, and ATC procedures are some of the possible means for coping with these visual limitations. To reduce the reliance of pilots on visual acquisition of other aircraft in busy terminal areas, the CASB recommends that:

> The Department of Transport take additional measures to ensure the safe and orderly passage of aircraft operating in visual meteorological conditions in the airspace around Canada's major airports.
>
> CASB 90-41

9.0 Information Transfer*

In 197 of the 362 Fact Finding Boards included in the database of this Special Investigation, a contributory or cause-factor relating to "communications" was assigned by Transport Canada; e.g., incorrect or unclear phraseology, failure to acknowledge or verify, inadequate coordination, inadequate sector briefing, transposition error, data posting error, data processing error, etc. In other words, in over half of the ATS occurrences investigated, communications- or information-transfer-related problems were found to be contributory.

In the United States, the frequency of communications-related problems may be even higher. Based on an analysis of approximately 70,000 reports to the U.S. Aviation Safety Reporting System (ASRS), approximately 80 per cent of the reports filed by pilots and controllers referred to ineffective information transfer via verbal communications. Consequently, in the United States, an industry working group was formed to identify significant communications areas of concern. The working group identified 12 areas for concern:

— Similar sounding alphanumerics

— Controller hearback problems

— Phraseology

— Enunciation

— Head-sets vs. speakers

— Radio discipline

— Intra-cockpit communications

— Inter-controller coordination communications

— Blocked or simultaneous transmissions

— Stuck microphones

— Readback problems

— Initial radio contact

The working group concluded that, if each and every pilot and controller recognized the 12 areas of concern identified by the working group and took action to eliminate the occurrence of particular problems existing in their own verbal communications loop, the benefits would be immediate in the quest to eliminate communications breakdowns.

* Further background information on information-transfer problems is contained in chapter 10 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

Most of the concerns raised by the American working group pertain to the Canadian occurrence experience. In addition, the file review and field survey phases of this Special Investigation revealed considerable mutual misunderstanding between pilots and controllers of their respective workloads. For example, one Boeing 737 pilot traversed 140 miles of Toronto Centre's airspace prior to contacting the Centre. On the other hand, one Fact Finding Board Report was critical of a pilot who allowed 66 seconds to elapse before contacting an arrival controller as instructed. While these are extremes, these two occurrences reflect a mutual lack of understanding and respect for the workload and responsibilities of other personnel key to the aircraft separation function.

In view of the frequency of irregularities and failures in the oral information transfer process and given the importance of effective inter-controller and controller/pilot communications to the safe separation of aircraft, the CASB believes that industry-wide action is required. Transport Canada, the professional associations such as CALPA and CATCA, and owners and operators could all play a role in improving the information transfer process. Promotional materials (e.g., safety articles, posters, videos, etc.) and familiarization visits (by pilots to ATC facilities and by controllers to cockpits of aircraft in flight) could help improve mutual understanding of the vulnerability of the oral communications process to human error.

9.1 Callsigns

With the expansion of the industry, many new airlines are adopting similar sounding company designators and/or flight numbers. While callsign confusion has caused few recent ATC loss-of-separation occurrences in Canada, feedback from pilots suggested that the problem is real and is growing. For example, companies operating in Canada now have a company designator with the term "Canadian" or "Express" in it, and, in many cases, flight numbers are virtually identical. Callsign confusion due to similar-sounding flight identifications is becoming a world-wide issue. Since the early 1970s, there have been efforts to develop computer programs that would permit alphanumeric callsign assignments with little or no risk of confusion with other aircraft operating in a particular airspace sector for periods of up to two hours. Indeed, the Investigators witnessed a demonstration of one very simple program (by the International Federation of Airline Pilots Associations) that converts current flight numbers to an alphanumeric format to be used in conjunction with the company designator for radio telephony purposes. Because the base includes the alphabet (vice 10 digits), this system would substantially reduce the statistical probability of similar sounding call signs/"flight numbers" occurring over the R/T at the same time and location — regardless of the actual flight numbers assigned by the company; i.e., the system would be transparent to all but the flight crew and ATC. In view of the potential consequences of a flight crew inappropriately responding to a clearance or instructions intended for another aircraft due to callsign confusion, the CASB recommends that:

> The Department of Transport and the Department of Communications develop and implement improved procedures for the assignment of callsigns (including company designators and flight numbers) to be used during radio telephony.
>
> CASB 90-42

9.2 Phraseology

While incorrect or unclear phraseology was cited in only 17 of the 362 Fact Finding Board Reports in the database, shortcomings in phraseology are much more commonplace. In examining the ATC tapes following an ATS operating irregularity, Transport Canada's Fact Finding Boards frequently identify a large number of deviations from standard phraseology during the preceding minutes leading up to the occurrence — even though they may not be directly contributory. While many of these are minor, they reflect a sloppiness which could eventually contribute to a breakdown in effective communications. For example, abbreviating callsigns, improper phonetics, grouping of numbers, omission of the term "flight level", incorrect pronunciation of numbers, etc. are frequently noted as deviations from the standard phraseology prescribed in MANOPS.

As noted previously, one of Transport Canada's quality control programs in ATS is the Phraseology Improvement Program (PIP). However, due to staff shortages and supervisory concentration on particular control positions, such programs are not being fully implemented. Indeed, in one occurrence, the Fact Finding Board determined that in a 15-minute period during which the loss of separation occurred, the controller committed no less than 64 procedural or phraseology errors.

Since the effectiveness of information transfer in aviation is highly dependent upon the use of standard phraseology, and given the widespread deviations from prescribed phraseology identified by Fact Finding Boards, clearly more emphasis on Transport Canada's Phraseology Improvement Program for air traffic controllers and flight service specialists is required.

9.3 Coordination

Of the 362 Fact Finding Board Reports in the database, inadequate coordination was cited by Transport Canada investigators 77 times. Indeed, coordination with other controllers, both inside and outside the unit, and with pilots is a critical element in effective air traffic control. Growing workload, single-controller sectors, inattention and distraction, procedural problems, and airspace configuration can all contribute to breakdowns in inter-controller coordination. Given the volume of oral information transfer required today, increasingly, efforts must be made to reduce coordination requirements between controllers and between controllers and pilots.

Transport Canada recognizes that many breakdowns in information transfer occur because of the need for controllers to regularly intervene in coordinating the communications process. Several initiatives currently being implemented will alleviate this condition; these include:

a) Inter-centre linking of the National Flight Data Processing System (NFDPS);

b) Gander Automated Message Processing System (GAMPS) to link the Centre with the International Flight Service Station;

c) Enhancements to the Gander Automated Air Traffic System (GAATS); and

d) The Canadian Automated Air Traffic System.

Recent changes to the legislation requiring a transponder with a Mode C capability for operations in Class C airspace and the control zones at Toronto and Vancouver should also reduce the coordination requirements. In addition, Transport Canada has assessed the feasibility of effecting electronic hand-offs from one ACC to another using the Joint Enroute Terminal System (JETS); it was concluded that, because of the complexity, it would not be practicable given the limited time that JETS will remain in service.

9.4 Gander Paper Handling

As mentioned earlier, Gander Oceanic Control relies very heavily upon HF radio communications with all the attendant problems, including the need for third party involvement in the communications process. This requires the International Flight Service Station at Gander to process 2,000 to 3,000 HF messages per day. Copying or typing errors often occur at this intermediary level as the requisite information is recorded for onward transmission. Ten teletypes and a team of operational support staff are then required to receive and run the information from the machines to the appropriate controllers. The resultant "paper-mill" has considerable potential for error.

Given the inherent vulnerabilities of the antiquated system of flight following using paper flight data strips in Gander Oceanic Control, and given the inherent vulnerabilities of oral communications through a third party using paper messages, the CASB recommends that:

> The Department of Transport take immediate steps to streamline the message handling process created by today's absence of direct controller/pilot communications in the Gander Oceanic Control Area.
>
> CASB 90-43

10.0 Management*

10.1 National Planning

In many respects, the quality of the current ATS system in Canada is a direct function of the quality of the long-term planning executed at the national level of the Department of Transport. To this end, Transport Canada does have several coherent plans to ensure the continuing effectiveness of the Air Navigation System beyond the year 2000. For example, the Canadian Airspace Systems Plan (CASP) identifies $5 billion worth of equipment considered necessary to modernize the diverse systems that comprise the Air Navigation System. If the more critical elements of the CASP can be implemented in accordance with the milestones therein, (e.g., RAMP and CAATS), then the long-term equipment needs of the Air Navigation System should be well met. To reflect user requirements, the Department pursues a rigorous consultative process with representatives of the aviation community. For example, in 1985 the Canadian Airspace Review was undertaken in cooperation with the aviation community; this review resulted in 600 recommendations, most of which are reported to be in various stages of implementation.

As mentioned earlier in this report, the most significant shortcoming in Transport Canada's national planning for the provision of air traffic services is in the area of staffing. The conflicting objectives of "downsizing" in government and accommodating growing air traffic levels have not been satisfactorily reconciled. It would appear that the Department's staff planning has focused more on meeting political and central agency requirements than on operational needs. Apparently, the standard tools for staff planning (e.g., multi-year operational plan, multi-year human resources plan, etc.) have failed to identify current and forecast shortcomings in staffing air traffic controllers positions and have offered too little remedial action too late. Transport Canada's current national staffing plan for air traffic controllers projects a get-well date of 1994. In other words, there will be at least four more years of operations under conditions of staff shortages. This situation is conducive to continued operating irregularities whereby the desired level of safety is frequently being compromised, increasing controller disenchantment and therefore early retirements of controllers, etc. Higher than forecast activity levels or controller attrition will only exacerbate this situation. A coherent, long-range, system-wide approach to staffing requirements for the ATS Branch, with new and innovative thinking, will be required to bridge the gap to the forecast get-well date. In view of the diverse ways by which current and expected staff shortages can undermine safety, the CASB recommends that:

> The Treasury Board and the Department of Transport provide the necessary resources in a timely manner to ensure resolution of the current staff crisis in the ATC system.
>
> CASB 90-44

* Further background information on management-related problems is contained in chapter 11 of the Staff Report on the CASB's Special Investigation into ATC Services in Canada.

10.2 Operational Decision-Making

The frequency of planning and judgement errors in the loss of separation occurrences reviewed reflects a fundamental need for change in the ATC system. (Planning or judgement factors were assigned by the Investigators in 163 of the 217 occurrences examined during the file review phase.) Today's ATC philosophy places almost exclusive reliance on tactical ATC methods. In other words, as workload increases additional controllers are introduced and/or the airspace is further subdivided; controllers then apply standard separation criteria in real-time as the air traffic situation evolves. To date, potential conflicts in air traffic are identified only as they occur. In many cases, they could be predicted and resolved earlier — as early as the flight planning phase; (the Gander Automated Air Traffic System is an example). Mode C or Mode S transponder equipment and automated hand-offs from one controller to another offer potential for reducing controller workload and coordination requirements. The Radar Modernization Project (RAMP) will have a conflict alerting capability which will also assist. But for the longer term, further software developments are required to build upon these technological gains so as to reduce the tactical workload by identifying potential conflicts as early as the flight planning stage.

Given today's technological capabilities and given the demonstrated weaknesses in the current ATC philosophy which is largely based upon tactical decision-making by controllers, the CASB recommends that:

> The Department of Transport refine its operating philosophy so as to achieve increased strategic decision-making and decreased tactical decision-making by controllers for the safe separation of aircraft.
>
> CASB 90-45

10.3 Employee/Management Relations

During the field survey phase of this Special Investigation, considerable feedback was received that an unhealthy "we/they" syndrome is developing in the provision of ATC services. While differences in perspective between management and employees are normal, there is sufficient anecdotal evidence to indicate a potential for serious breakdowns in employee/management communications which could adversely affect safety.

The Investigators were generally impressed with the shared perspective of problems facing the ATC community today, as indicated by journeymen controllers up through the various levels of supervision and management, to the unit chief level. However, at the national level, there seems to be significant differences in perspective. At the operational units visited, there was considerable consensus concerning the effects of high workload, excessive overtime, lack of effective supervision, etc. on controller morale and performance. At the national level, such issues were seen as largely self-induced at the local level. Such fundamental differences do little to enhance employee confidence in management (or vice versa).

Employee confidence in management seems to be cyclical. New senior management at two of the Centres visited has reportedly contributed to significant improvements in local morale. However, at all four of the units visited, comments were received from every level of management interviewed, on the totally unsatisfactory first-line supervisory situation today. This general breakdown in the supervisory chain has in large measure broken managerial

contact in the operational units. Confidence in management is further eroded by a pervasive sense that "nobody is listening to us"; any failure of management to respond to individual controller's concerns (e.g., as expressed through the Operational Conditional Reporting program) further contributes to this feeling.

While the investigating team found nothing to indicate any general lack of competence by today's air traffic controllers, the investigators did hear surprising comments with respect to the handling of weak controllers; for example, in particular subunits, not all ATS operating irregularities or breakdowns in controller discipline are being appropriately reported to management. Given the absence of an effective managerial presence, some controllers may even be taking the issue of controller competence into their own hands — protecting their peers (and possibly even supervisors) from time to time and reporting occurrences on any member who does not fit into that team well. Yet even when management is aware of a weak controller, given current staff shortages, they have been reluctant to take action.

Safe separation of air traffic is dependent upon the maintenance of the highest standards of discipline and performance. In view of the apparent shortcomings in employee/management relations in the busiest centres, the CASB recommends that:

> The Department of Transport implement measures to re-establish an effective managerial presence in ATC operations.
>
> CASB 90-46

10.4 Safety Promotion

Transport Canada has very effective safety promotion programs in place throughout the aviation community for pilots, owners and operators, and servicing and maintenance personnel. There does not seem to be an equivalent level of attention given to the promotion of aviation safety in the ATS Branch. While the effectiveness of safety promotion programs in reducing aviation occurrences is difficult to measure, the CASB notes that organizations with good safety records almost invariably foster safety awareness among their employees through safety promotion programs. Therefore the CASB recommends that:

> The Department of Transport develop and implement a comprehensive program for the promotion of safety awareness throughout ATS operations.
>
> CASB 90-47

10.5 Unit Evaluations

The ATS Branch has an Evaluation Division which has a two-fold responsibility: conducting unit evaluations across the country and convening Fact Finding Boards for the investigation of ATC operating irregularities. At the time of the field survey phase of this Special Investigation, only one of the four ACCs visited had recently undergone a comprehensive unit evaluation by the Evaluation Division. Since 1988, there has been a concentrated effort to increase the evaluation effort. Thus, Transport Canada reports that, as of November 1989, two more of the four ACCs had been evaluated and that all ATC units have been evaluated within the last three years, which is in keeping with their ATS evaluation policy. Nevertheless, it is suspected that the Division's heavy involvement in the investigation of

ATC operating irregularities may have compromised its ability to systematically conduct unit evaluations. In other words, by focusing on individual occurrences, the Evaluation Division may have missed the opportunity to reduce the number of occurrences through the early identification of problem areas during unit evaluations.

The current staffing crisis, the frequency of serious ATC operating irregularities, the forthcoming implementation of significant equipment enhancements, forecast traffic growth for the next decade, and anticipated high staff turnover, all suggest a need for an extraordinary effort to ensure the maintenance of quality control. Therefore the CASB recommends that, during this highly dynamic period:

> The Department of Transport increase its efforts for monitoring ATC operations through unit evaluations to ensure the consistent application of prescribed standards and procedures.
>
> (CASB 90-48)

10.6 Investigation of ATS Occurrences

Following any reported ATS occurrence, the CASB decides whether or not the circumstances warrant a CASB investigation. If not, Transport Canada may conduct a Fact Finding Board into the ATS operating irregularity.

Notwithstanding the quality of Fact Finding Board reports reviewed by the CASB, there is a perception among the controllers interviewed that independence and objectivity are lacking in Transport Canada's Fact Finding Board process. Mr. Justice Charles L. Dubin stated in his "Report of the Commission of Inquiry on Aviation Safety", (May 1981, Volume 1):

> "Virtually all the same arguments in favour of an independent tribunal for accident investigation apply with equal force to incident investigation. For these reasons, I am of the opinion that the jurisdiction to investigate all incidents relating to civil aircraft should be assigned to an independent tribunal ... That would include incidents which may be related to air traffic controllers ... "

While the CASB investigated 75 of the 710 loss of separation occurrences in the database used for this Special Investigation, the CASB's focus has been on those occurrences where the circumstances brought the aircraft closest to an accident. Yet, in the 362 Fact Finding Board Reports in this investigation's database, there were many which involved aircraft that were dangerously close to each other; in 17 per cent (of 207 occurrences) Transport Canada judged that there was a real risk of collision and in a further 18 per cent, there was a critical loss of separation.

Indeed, in 103 occurrences in the database, the loss of separation was such as to warrant the initiation of evasive action by the pilot.

Notwithstanding the fact that there have been no midair collisions involving an aircraft over 12,500 pounds maximum take-off weight in Canada since 1970, the factors contributing to loss of separation occurrences frequently have potential for creating real risk for collision. Therefore, to maintain a safe ATS system, the factors contributing to such losses of separation occurrences should be fully investigated, understood, and recorded on an

individual basis, so as to facilitate analysis and understanding on a macro-basis. Historically, neither the CASB nor Transport Canada has consistently identified and recorded the pertinent human performance factors contributing to risk of collision occurrences.

During the file review phase of this Special Investigation, it was found that under Transport Canada's Fact Finding Board process, managerial considerations do not appear to have come under the same critical scrutiny as individual controllers' work habits and procedures; for example, it is believed that equipment, staffing, and supervisory-related problems have often created the operational context which facilitated air traffic controllers' errors. In reviewing the occurrences investigated by CASB, the Special Investigators also found shortcomings with respect to the consistency of data recorded by the CASB for future analytical purposes. In part, this is attributable to the slow development of an adequate ATS expertise on the CASB staff and slow definition of the investigation and reporting standards for incidents involving losses of separation between aircraft.

In view of the diverse and pervasive nature of the shortcomings in the ATS operating system today as revealed through this Special Investigation, the CASB has decided to improve the investigation of ATS occurrences by:

— Redefining the decision-making process by which the CASB decides to investigate risk-of-collision occurrences.

— Increasing the in-house capability of the CASB to investigate ATS occurrences by creating new controller positions for the investigation and analysis of ATS occurrences.

— Developing improved standards for the consistent collection and recording of data relating to ATS occurrences, regardless of whether the CASB or Transport Canada investigates the occurrence.

— Requiring that final reports on any ATS occurrences investigated by Transport Canada are formally monitored by the CASB to facilitate macro-analysis.

Progress on these initiatives will be reported to Parliament.

11.0 Conclusion

The CASB believes that the foregoing report provides a balanced perspective on the overriding safety considerations in the provision of air traffic services in Canada. While the examination has not been exhaustive, the data examined and witness statements provided are representative of problems with serious safety implications across the country. This special investigation does not focus on any single event but takes a broad view of the ATS system.

The Board acknowledges the initiatives of the Minister of Transport and his officials both in response to and in parallel with the Board's work over the past year. In some cases, the Board is aware that appropriate safety action has been completed; so no recommendation is made. In other cases, corrective action has been initiated, but a safety recommendation has been made to encourage ministerial support in resolving the associated safety deficiency. Although the ATS system is operating well in most respects, urgent ministerial attention to the major issues addressed in this report is required to correct the identified deficiencies and ensure the safe separation of aircraft. In particular, the current staff shortages must be redressed to facilitate implementation of many of the other recommendations.

Success in sustaining the requisite levels of safety will be predicated upon the Government's recognition of the breadth and depth of the problems and its assurance of the necessary resources to correct the growing shortcomings.

This report and the safety recommendations therein have been adopted by the Chairman, K.J. Thorneycroft, and Members:

L. Filotas
W. MacEachern
A. Portelance
B. Pultz
R. Stevenson
F. Thurston

Member N. Bobbitt abstained.

ANNEX A

GLOSSARY

ACC	Area Control Centre
ADS	Automatic Dependent Surveillance
AGCS	Air Ground Communications System
ANO	Air Navigation Order
ASDE	Airport Surface Detection Equipment
ASRS	Aviation Safety Reporting System
ATAC	Air Transport Association of Canada
ATC	Air Traffic Control
ATCOH	Air Traffic Control Occupational Health
ATS	Air Traffic Services
CAATS	Canadian Automated Air Traffic System
CADORS	Civil Aviation Daily Occurrence Reporting System
CALPA	Canadian Airline Pilots Association
CASB	Canadian Aviation Safety Board
CASP	Canadian Airspace Systems Plan
CATCA	Canadian Air Traffic Control Association
CBAA	Canadian Business Aircraft Association
CRT	Cathode Ray Tube
DCPC	Direct Controller/Pilot Communications
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIR	Flight Information Region
GAATS	Gander Automated Air Traffic System
GAMPS	Gander Automated Message Processing System
HF	High Frequency
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IM	Indicator Module
IMC	Instrument Meteorological Conditions
JETS	Joint Enroute Terminal System
LBPIA	Lester B. Pearson International Airport
MANOPS	Manual of Operations
MNPS	Minimum Navigation Performance Specification
NACS	Northern Airspace Control System
NATS	National Air Traffic Control Simulator
NFDS	National Flight Data Processing System

OIDS	Operational Informational Display System
OJI	On-the-job Instructor
OJT	On-the-job Training
PAL	PeripherAL
PIP	Phraseology Improvement Program
RAMP	Radar Modernization Project
RDPS	Radar Data Processing System
TCAS	Traffic Alert and Collision Avoidance System
TCTI	Transport Canada Training Institute
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions